Advantages of Using Measures versus Scores for Aging Research

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Aging and Rehabilitation Seminar Series
April 10, 2006

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Purpose

- To identify the characteristics and limitations of scores
- To contrast scores with measures
- To learn about applications of measures in research and clinical intervention

Benjamin Wright

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Problem with "Measurement" in the Social Sciences

(Institute for Objective Measurement, 2000)

- Most measurement efforts in the social sciences tally differently sized test or survey answers and stop there, mistakenly treating these concrete counts as abstract measures of amount.

"Raw scores, like raw rhubarb, will only make you sick."

- Technically, raw scores are simply frequency counts
  - Scores on an academic test - number of items correct
  - Scores on our rating-scale instruments – sum of Likert ratings
- Test dependent
- Sample dependent

Measures

- Numbers that deserve to be called “measures”.
  - e.g., inches, dollars, degrees, pounds
- “Each unit is a perfect idea which can only approximated in practice”

The Ruler

- The inch on any ruler is not perfect, but what it represents is perfect.
  - Standardized
  - Sample free
  - Test free
  - Efficient
  - Precise

Definition of Objective Measurement

(Institute for Objective Measurement, 2000, www.rasch.org)

- Objective measurement is the repetition of a unit amount that maintains its size, within an allowable range of error, no matter which instrument is used to measure the variable of interest (test free) and no matter who or what relevant person or thing is measured (sample free).

"Clarity of thought is essential, statistical gymnastics is for Psychometrika [journal]"

"Unless you can show me your exact solution is better than my approximate solution, I am not interested in your exact solution"

Rasch Measurement Model

– Both necessary and sufficient for objective measurement

Rasch Formula

$$\text{In } [P_{ni}/1\text{-}P_{ni}] = B_n - D_i$$

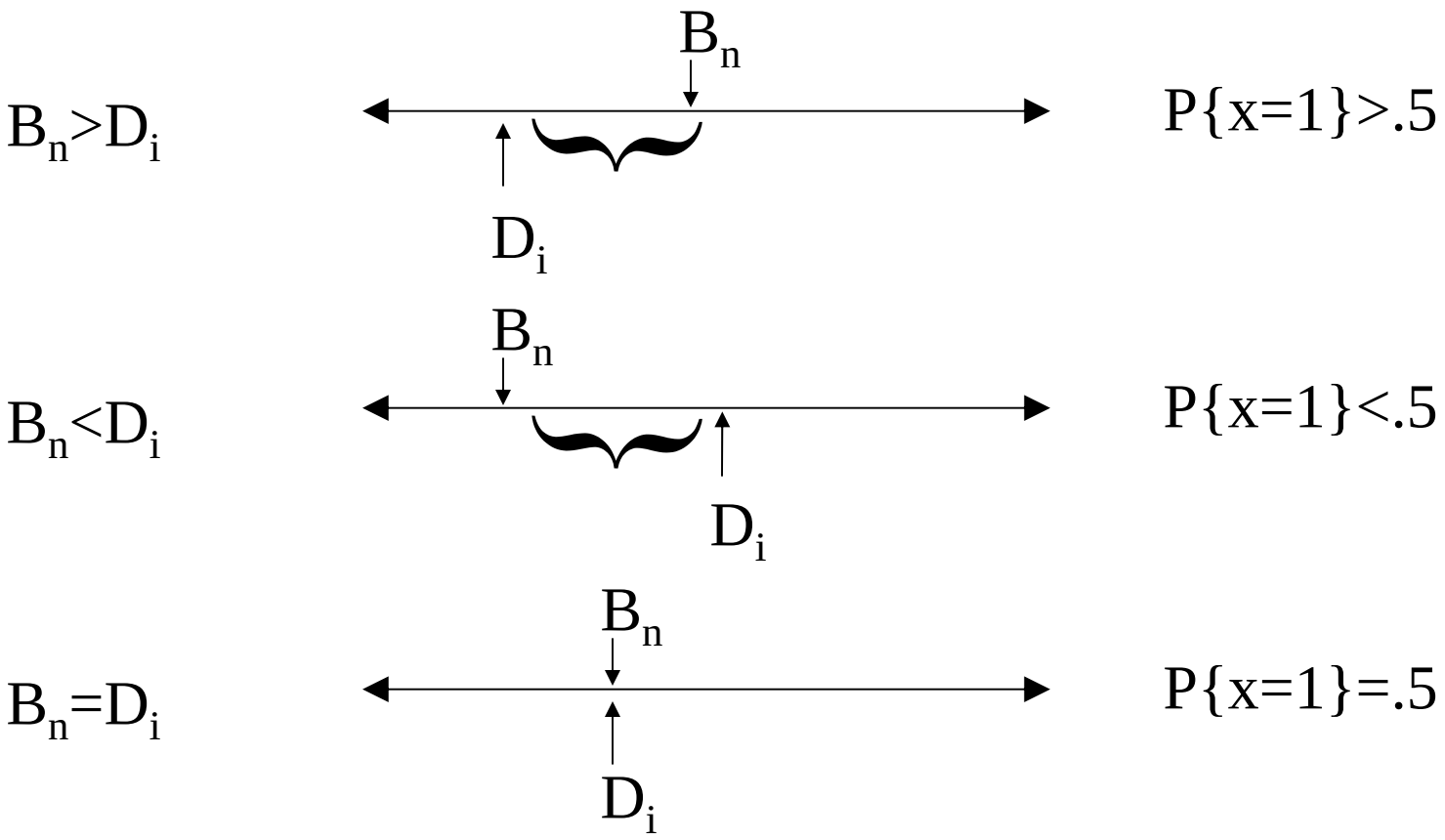
P_{ni} = probability of person *n* passing item *i*

$1\text{-}P_{ni}$ = probability of person *n* failing item *i*

B_n = ability of person *n*

D_i = difficulty of item *i*

How Person Ability and Item Difficulty Affect the Probability of a Correct Response



Rasch Model & Measuring Physical Ability in Rehabilitation

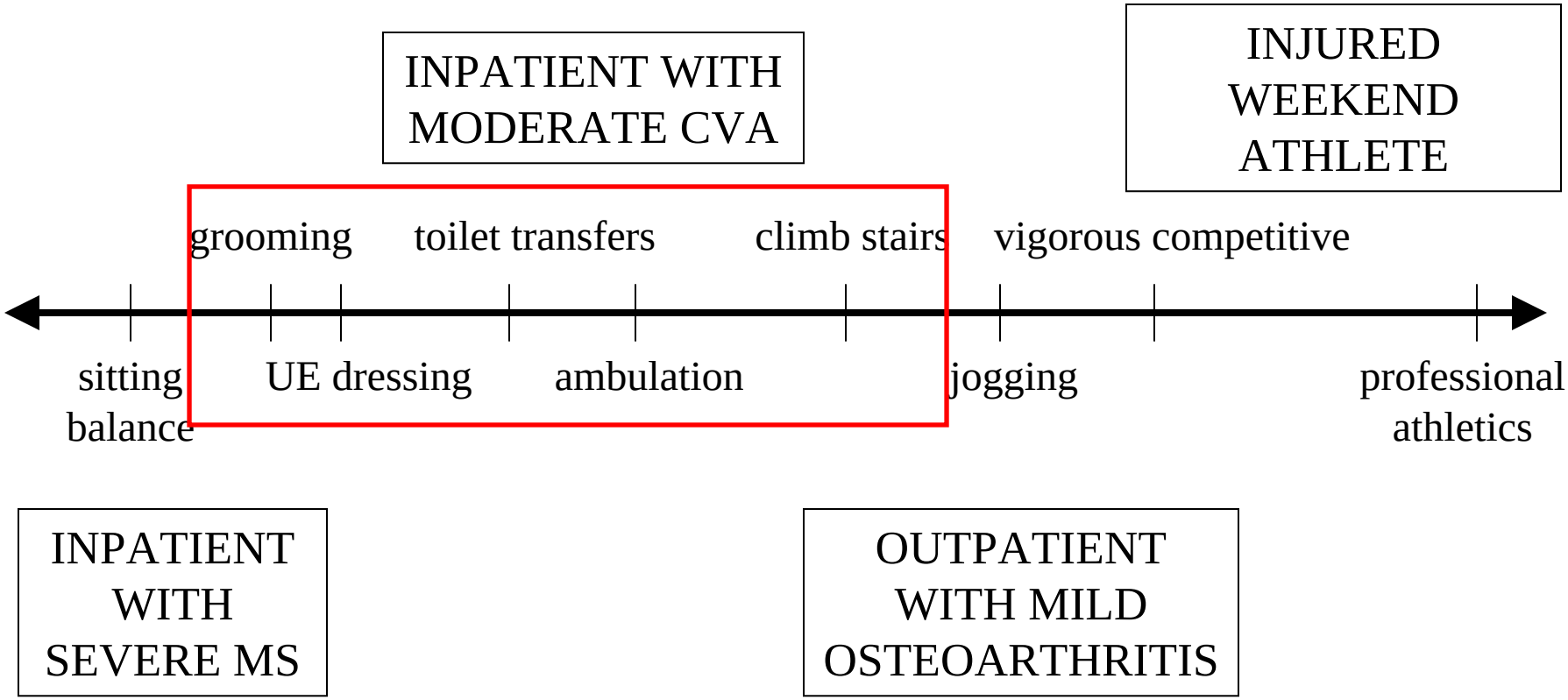
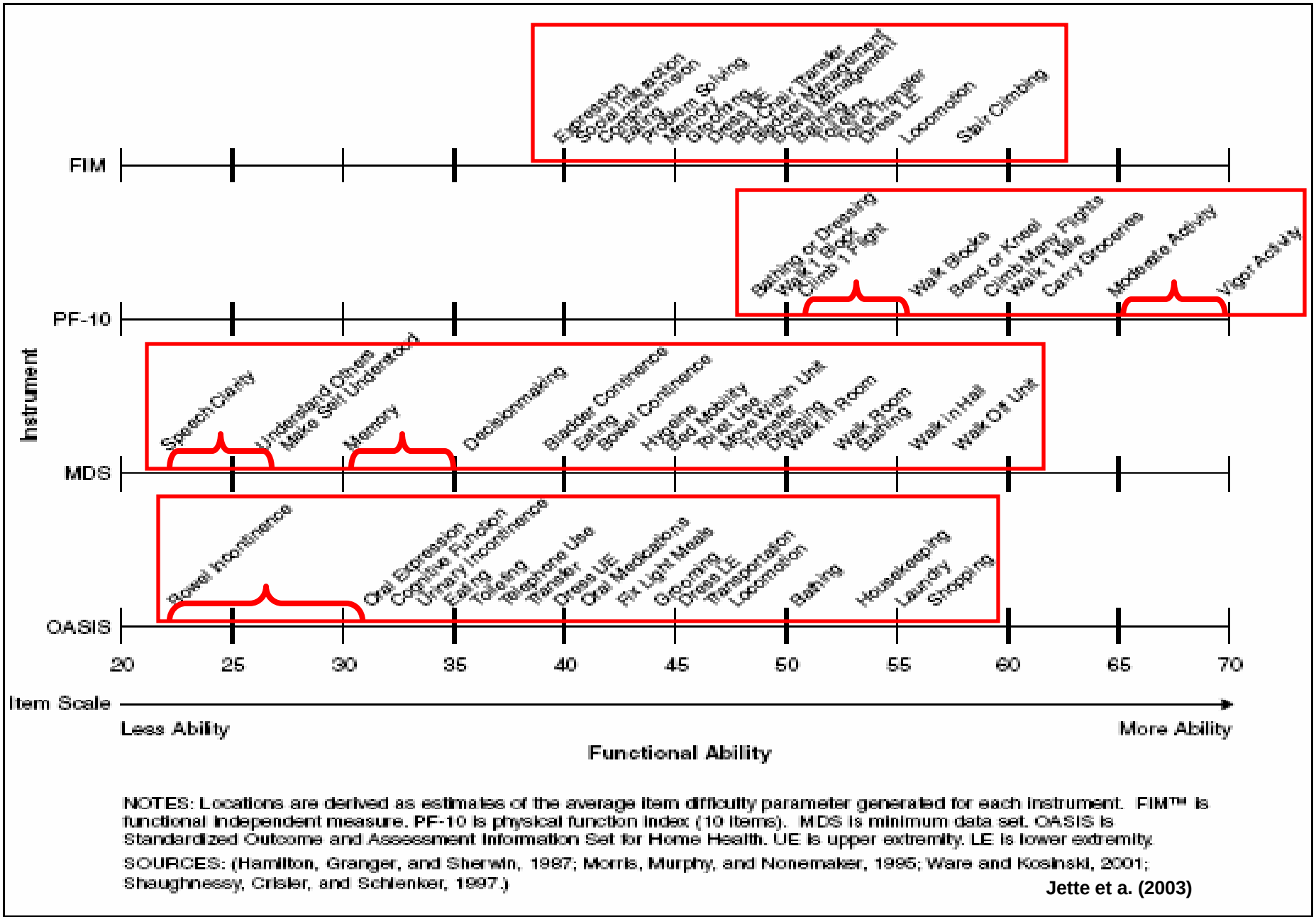


Figure 1

Rasch Model Comparison of the Four Post-Acute Care Instruments



NOTES: Locations are derived as estimates of the average item difficulty parameter generated for each instrument. FIM™ is functional independent measure. PF-10 is physical function index (10 items). MDS is minimum data set. OASIS is Standardized Outcome and Assessment Information Set for Home Health. UE is upper extremity. LE is lower extremity.

SOURCES: (Hamilton, Granger, and Sherwin, 1987; Morris, Murphy, and Nonemaker, 1995; Ware and Kosinski, 2001; Shaughnessy, Crisler, and Schlenker, 1997.)

Jette et a. (2003)

“You do not understand what you are measuring, unless you understand the difficulty of your items.”

- Most of our instruments are created by generating items under a construct (e.g., physical ability, depression, self esteem), without any concern about how much of that construct is represented by each item.

Rosenberg Self Esteem Scale

Instructions: Below is a list of statements dealing with your general feelings about yourself. If you strongly agree, circle **SA**. If you agree with the statement, circle **A**. If you disagree, circle **D**. If you strongly disagree, circle **SD**.

1.	On the whole, I am satisfied with myself.	SA	A	D	SD
2.*	At times, I think I am no good at all.	SA	A	D	SD
3.	I feel that I have a number of good qualities.	SA	A	D	SD
4.	I am able to do things as well as most other people	SA	A	D	SD
5.*	I feel I do not have much to be proud of.	SA	A	D	SD
6.*	I certainly feel useless at times.	SA	A	D	SD
7.	I feel that I'm a person of worth, at least on an equal plane with others.	SA	A	D	SD
8.*	I wish I could have more respect for myself.	SA	A	D	SD
9.*	All in all, I am inclined to feel that I am a failure.	SA	A	D	SD
10.	I take a positive attitude toward myself.	SA	A	D	SD

"There have been no significant advances in the social sciences due to our failure to understanding what we are measuring."

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Using the Rasch Model to Support/Challenge Theory

Examination of the Measurement Properties of the Fugl-Meyer Upper Extremity Assessment

Woodbury, ML,. Velozo, CA., Richards, LG., Duncan,P, Studenski S, Lai SM, Perera S. (2006)

Fugl-Meyer Upper Extremity (UE) Assessment

- Most used post-stroke UE clinical assessment in research
- Primary outcome measure in most post-stroke UE rehabilitation studies (50 articles in 2005)
  - **"Gold Standard"**
  - Quantification of **UE motor ability**
  - Stratify patients into homogenous subgroups
  - Predict long-term participation

	Shoulder/Elbow/Forearm
Item 1	Biceps reflex elicited
Item 2	Triceps reflex elicited
Item 3	Scapular elevation
Item 4	Scapular retraction
Item 5	Shoulder abduction
Item 6	Shoulder external rotation
Item 7	Elbow flexion
Item 8	Forearm supination
Item 9	Shoulder adduction with internal rotation
Item 10	Elbow extension
Item 11	Forearm pronation
Item 12	Hand to lumbar spine
Item 13	Shoulder flexion to 90° degrees with elbow extended
Item 14	Pronation–supination of forearm with elbow at 90°
Item 15	Shoulder abduction to 90° with elbow extended
Item 16	Shoulder flexion to 90°-180° with elbow extended
Item 17	Pronation–supination of forearm with elbow extended
Item 18	Normal reflex activity
	Wrist
Item 19	Wrist stable with elbow at 90°
Item 20	Wrist flexion-extension with elbow at 90°
Item 21	Wrist stable with elbow extended and shoulder at 30°
Item 22	Wrist flexion-extension with elbow extended and shoulder at 30°
Item 23	Wrist circumduction
	Hand
Item 24	Finger mass flexion
Item 25	Finger mass extension
Item 26	Hook grasp (MPs extended, PIPs and DIPs flexed)
Item 27	Lateral prehension (thumb adduction to hold paper)
Item 28	Palmar pinch (thumb to index finger to hold pencil)
Item 29	Cylindrical grasp (hold small can)
Item 30	Spherical grasp (hold tennis ball at fingertips)
	Coordination/Speed
Item 31	Movement without tremor
Item 32	Movement without dysmetria
Item 33	Movement with normal speed

Rating Scale and Scoring

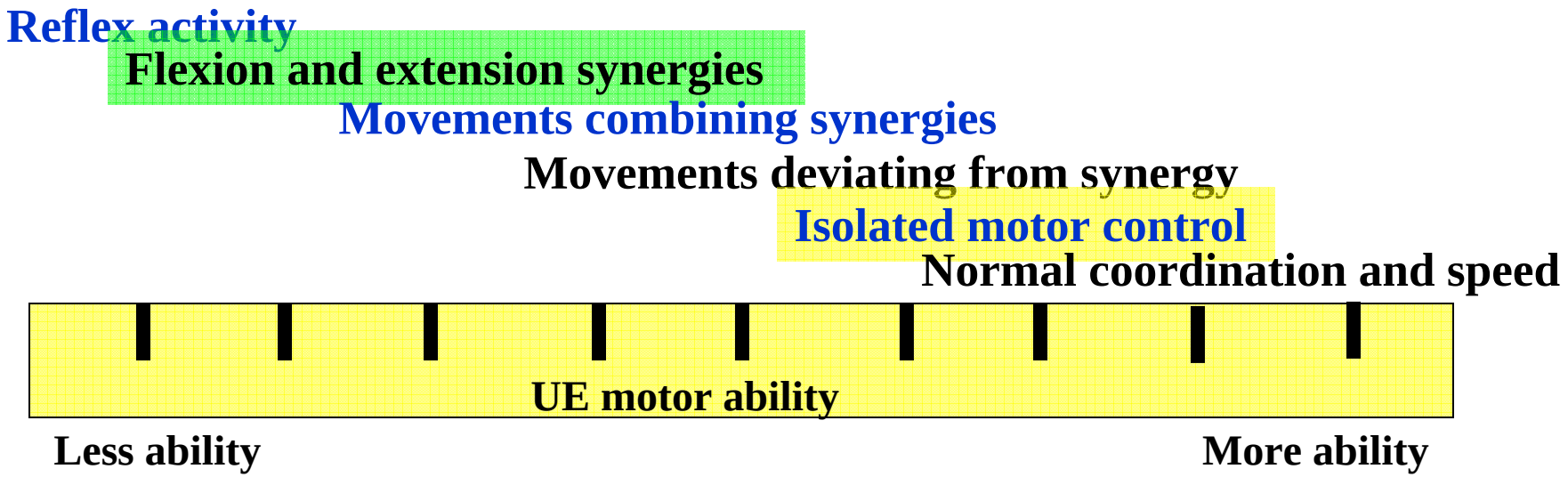
Each of the 33 items scored

- 0 = unable to perform movement
- 1 = ability to partially perform motion
- 2 = normal movement

- Scores summed reported as aggregate raw score (out of 66)

Theoretical Basis?

"Motor recovery following hemiplegia proceeds according to a definable stepwise course" (Twitchell 1951, Brunnstrom 1970, Fugl-Meyer 1975)



Is this "ruler" correct?

Methods

- Retrospective analysis
- 512 persons 0 – 6 months post mild to severe ischemic stroke
- Kansas City Pepper Study and Kansas City Stroke Study
- FMA-UE administered at admission to study participants

Duncan, PW., Richards, LG. (1998, 2003)

Item Description	Component 1
Elbow Extension	0.91
Forearm Pronation	0.91
Pronation Supination with Elbow 90	0.91
Wrist Flexion Extension Elbow 90	0.90
Sh Flex to 90 Elbow Extended	0.90
Shoulder Adduction with IR	0.90
Finger Mass Extension	0.90
Hand to Lumbar Spine	0.89
Sh Abd to 90 Elbow Extended	0.88
Finger Mass Flexion	0.88
Elbow Flexion	0.88
Cylindrical Grasp	0.88
Shoulder Abduction	0.88
Shoulder External Rotation	0.88
Pronation Supination with Elbow Extended	0.87
Forearm Supination	0.86
Wrist Stable Elbow at 90	0.86
Scapular Elevation	0.85
Palmar Prehension	0.85
Wrist Flexion Extension Elbow Extended	0.85
Movement without tremor	0.84
Scapular Retraction	0.84
Sh Flex to 180 Elbow Extended	0.83
Wrist Stable Elbow Extended	0.83
Movement with normal speed	0.81
Wrist Circumduction	0.80
Lateral Prehension	0.80
Spherical Grasp	0.80
Movement without dysmetria	0.78
Hook Grasp	0.75
Biceps Reflex	0.24
Triceps Reflex	0.14
Normal Reflex Activity	0.53

Initial Analysis

30 of 33 items exhibit strong correlations ($r = 0.75 – 0.91$) with first component

"More Difficult"

FMA-UE item number	FMA-UE Category	FMA-UE item description	Measure	Error
23		Wrist circumduction	1.67	0.10
26	Hand	Hook grasp	1.33	0.10
16		Shoulder flexion to 180°, elbow extended	1.26	0.10
30	Hand	Spherical grasp	1.20	0.10
27	Hand	Lateral prehension	1.08	0.10
22		Wrist flexion-extension, elbow extended	1.06	0.10
17		Pronation-supination, elbow extended	1.00	0.10
21		Wrist stable, elbow extended	0.95	0.10
33		Movement with normal speed	0.89	0.10
8	Flexor Synergy	Forearm supination	0.65	0.10
15		Shoulder abduction to 90°, elbow extended	0.28	0.10
32		Movement without dysmetria	0.27	0.10
6	Flexor Synergy	Shoulder external rotation	0.24	0.10
19		Wrist stable, elbow at 90°	0.18	0.10
20		Wrist flexion-extension, elbow at 90°	0.12	0.10
28	Hand	Palmar prehension	0.06	0.10
4	Flexor Synergy	Scapular retraction	0.03	0.10
14		Pronation-supination, elbow at 90°	-0.17	0.11
13		Shoulder flexion to 90°, elbow extended	-0.21	0.11
12		Hand to lumbar spine	-0.40	0.11
5	Flexor Synergy	Shoulder abduction	-0.56	0.11
10		Elbow extension	-0.64	0.11
11		Forearm pronation	-0.87	0.11
31		Movement without tremor	-0.91	0.11
29	Hand	Cylindrical grasp	-1.10	0.12
25	Hand	Finger mass extension	-1.25	0.12
3	Flexor Synergy	Scapular elevation	-1.40	0.12
24	Hand	Finger mass flexion	-1.44	0.12
9		Shoulder adduction with internal rotation	-1.56	0.12
7	Flexor Synergy	Elbow flexion	-1.76	0.13

"Easy"

More UE Ability

Less UE Ability

Wrist circumduction
Hook grasp
Shoulder flexion to 180°, elbow extended
Spherical grasp
Lateral prehension
Wrist flexion-extension, elbow extended
Pronation-supination, elbow extended
Wrist stable, elbow extended
Movement with normal speed
Forearm supination
Shoulder abduction to 90°, elbow extended
Movement without dysmetria
Shoulder external rotation
Wrist stable, elbow at 90°
Wrist flexion-extension, elbow at 90°
Palmar prehension
Scapular retraction
Pronation-supination, elbow at 90°
Shoulder flexion to 90°, elbow extended
Hand to lumbar spine
Shoulder abduction
Elbow extension
Forearm pronation
Movement without tremor
Cylindrical grasp
Finger mass extension
Scapular elevation
Finger mass flexion
Shoulder adduction with internal rotation
Elbow flexion

3rd class lever

Items are “easy” or “hard” depending on the inherent mechanical demands of the task

Multiple joint movement

Flexion at a single joint

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Conclusions

- Reflex items are disconnected from rest of assessment
  - Different neurological mechanism therefore different construct

- UE motor recovery does not proceed in the "stepwise" sequence proposed by previous clinical researchers.
  - **Not** proximal-to-distal
  - Not synergistic-to-isolated

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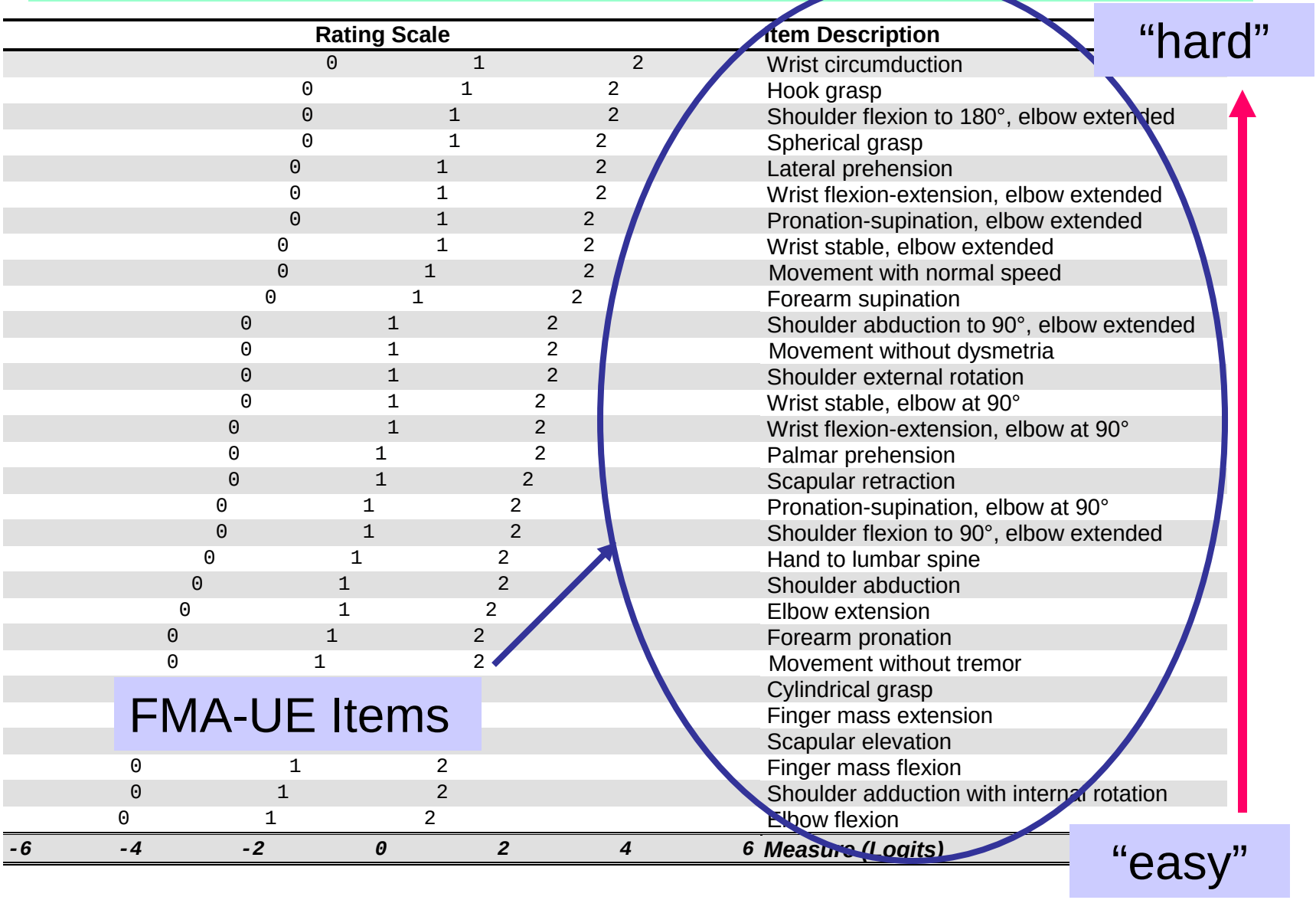
Using the Rasch Model to Inform Treatment

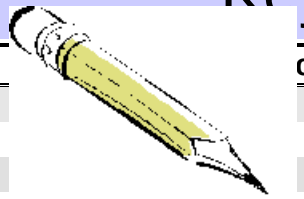
Use of Keyforms to Identify Short Term and Long Term Goals

Woodbury, M. & Velozo, C.A.

“Keyform” Recovery Map



Keyform ("recovery map")



cale	Item Description
1 2	Wrist circumduction
1 2	Hook grasp
1 2	Shoulder flexion to 180°, elbow extended
1 2	Spherical grasp
0 1 2	Lateral prehension
0 1 2	Wrist flexion-extension, elbow extended
0 1 2	Pronation-supination, elbow extended
0 1 2	Wrist stable, elbow extended
0 1 2	Movement with normal speed
0 1 2	Forearm supination
0 1 2	Shoulder abduction to 90°, elbow extended
0 1 2	Movement without dysmetria
0 1 2	Shoulder external rotation
0 1 2	Wrist stable, elbow at 90°
0 1 2	Wrist flexion-extension, elbow at 90°
0 1 2	Palmar prehension
0 1 2	Scapular retraction
0 1 2	Pronation-supination, elbow at 90°
0 1 2	Shoulder flexion to 90°, elbow extended
0 1 2	Hand to lumbar spine
0 1 2	Shoulder abduction
0 1 2	Elbow extension
0 1 2	Forearm pronation
0 1 2	Movement without tremor
0 1 2	Cylindrical grasp
0 1 2	Finger mass extension
0 1 2	Scapular elevation
0 1 2	Finger mass flexion
1 2	Shoulder adduction with internal rotation
1 2	Elbow flexion
-2 0 2 4 6	***Measure (Logits)***

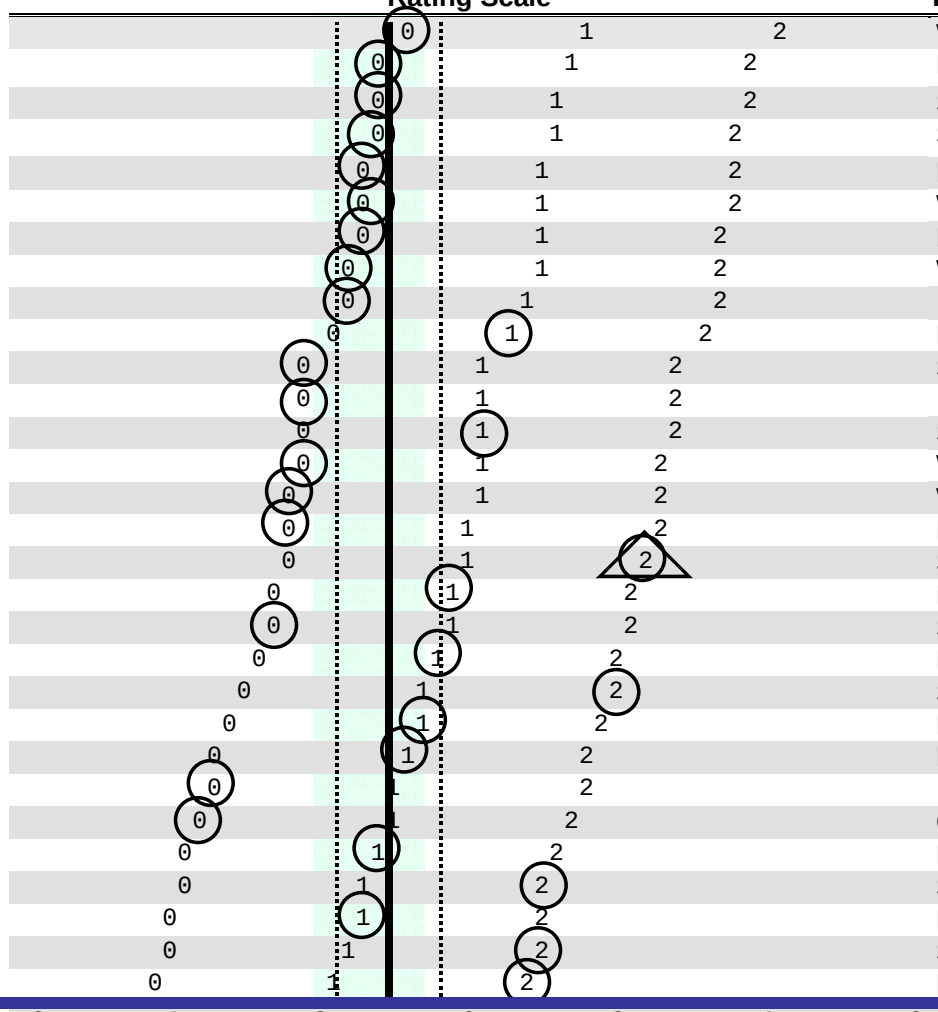
0 = "unable"

1 = "partial"

2 = "faultless"

SEVERE Upper Extremity Impairment

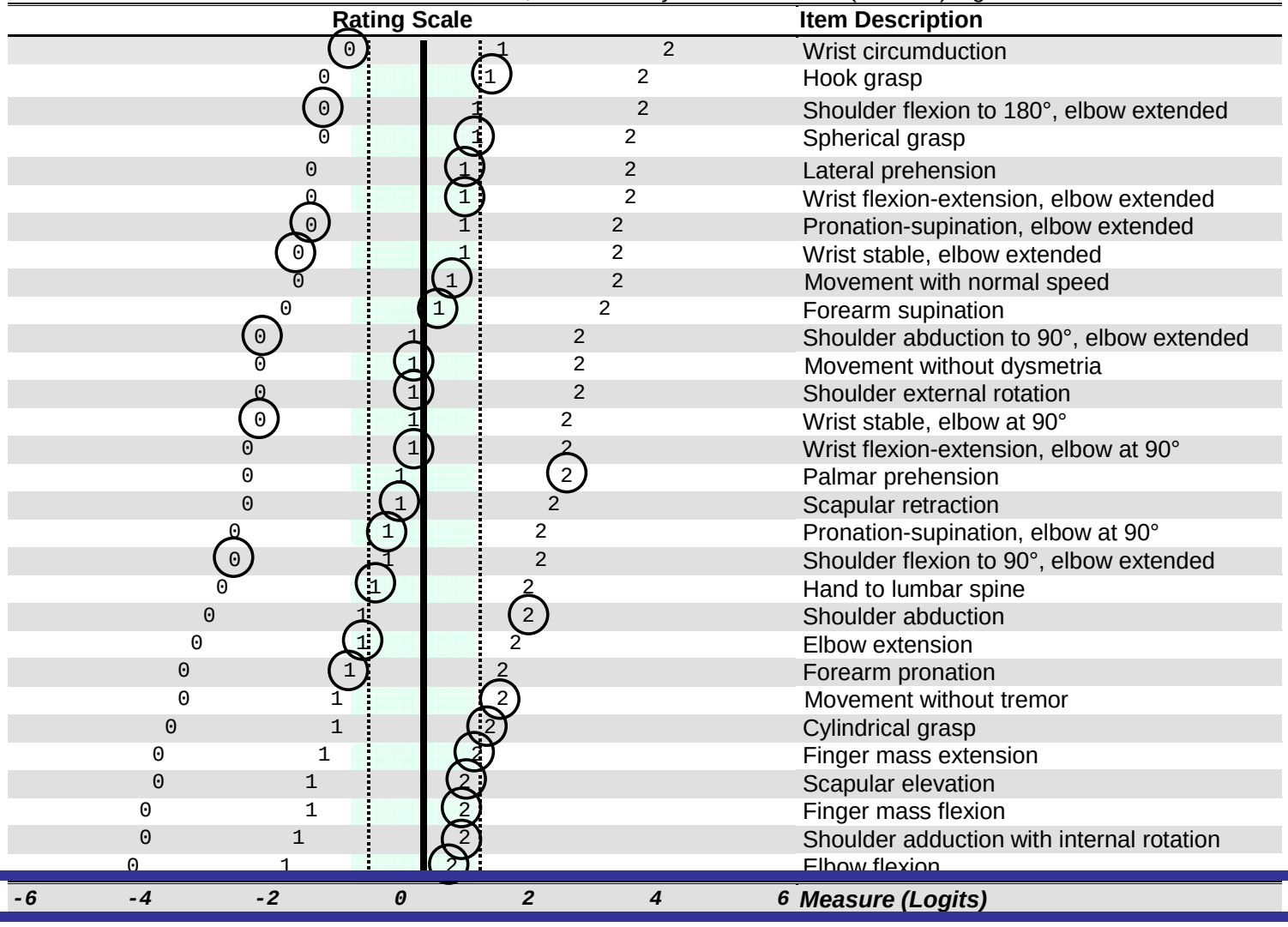
Individual with Severe Upper Extremity Motor Impairment
FMA-UE Score = 18/60, Rasch Ability Measure = -1.25 (SE 0.34) logits



Rating Scale	Item Description
	Wrist circumduction
	Hook grasp
	Shoulder flexion to 180°, elbow extended
	Spherical grasp
	Lateral prehension
	Wrist flexion-extension, elbow extended
	Pronation-supination, elbow extended
	Wrist stable, elbow extended
	Movement with normal speed
	Forearm supination
	Shoulder abduction to 90°, elbow extended
	Movement without dysmetria
	Shoulder external rotation
	Wrist stable, elbow at 90°
	Wrist flexion-extension, elbow at 90°
	Palmar prehension
	Scapular retraction
	Pronation-supination, elbow at 90°
	Shoulder flexion to 90°, elbow extended
	Hand to lumbar spine
	Shoulder abduction
	Elbow extension
	Forearm pronation
	Movement without tremor
	Cylindrical grasp
	Finger mass extension
	Scapular elevation
	Finger mass flexion
	Shoulder adduction with internal rotation
	Elbow flexion
-6 -4 -2 0 2 4 6	***Measure (Logits)***

MODERATE Upper Extremity Impairment

Individual with Moderate Upper Extremity Motor Impairment
FMA-UE Score = 32/60, Rasch Ability Measure = 0.20 (SE 0.32) logits



MILD Upper Extremity Impairment

Individual with Mild Upper Extremity Motor Impairment
FMA-UE Score = 57/60, Rasch Ability Measure = 3.88 (SE 0.62) logits

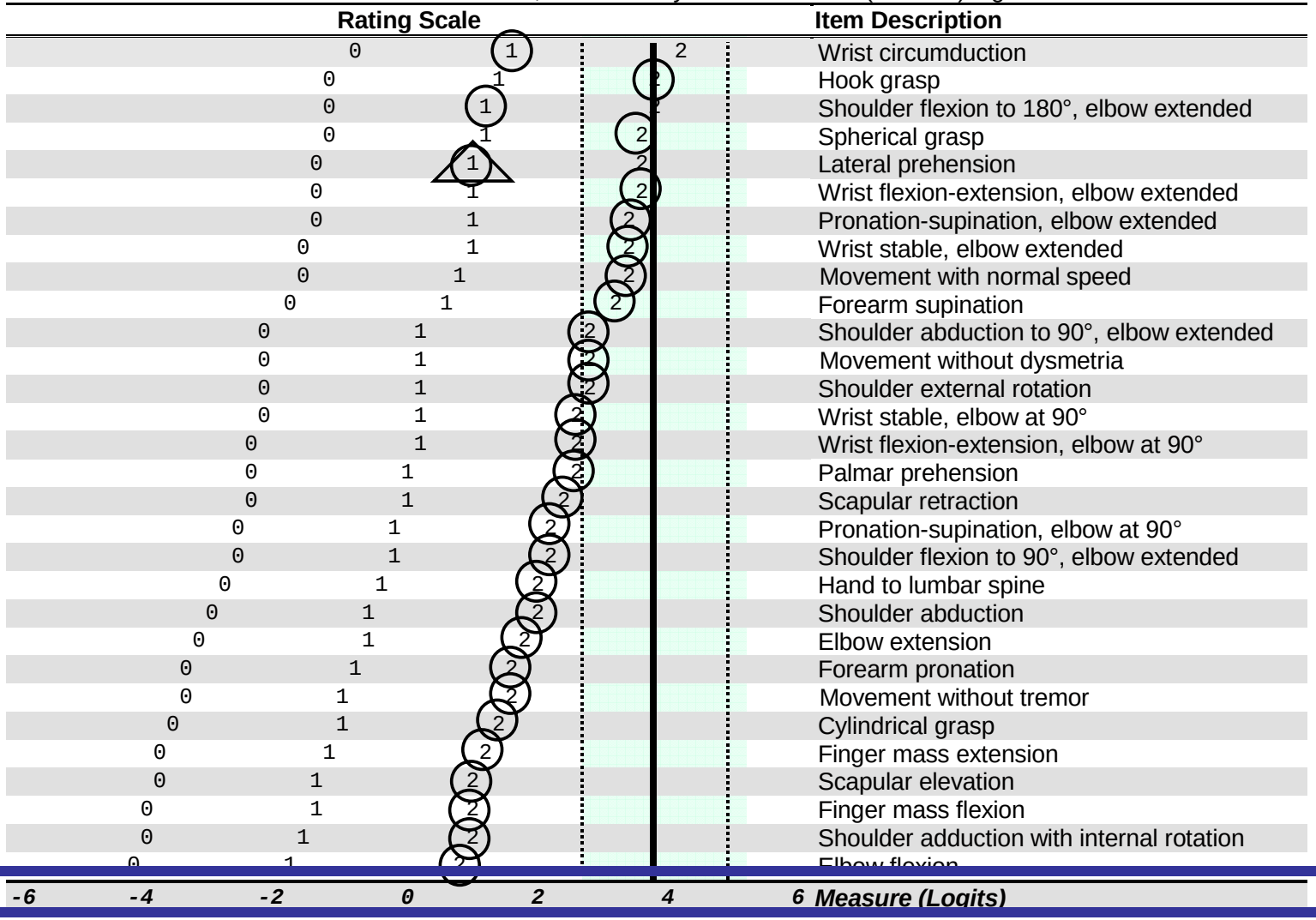
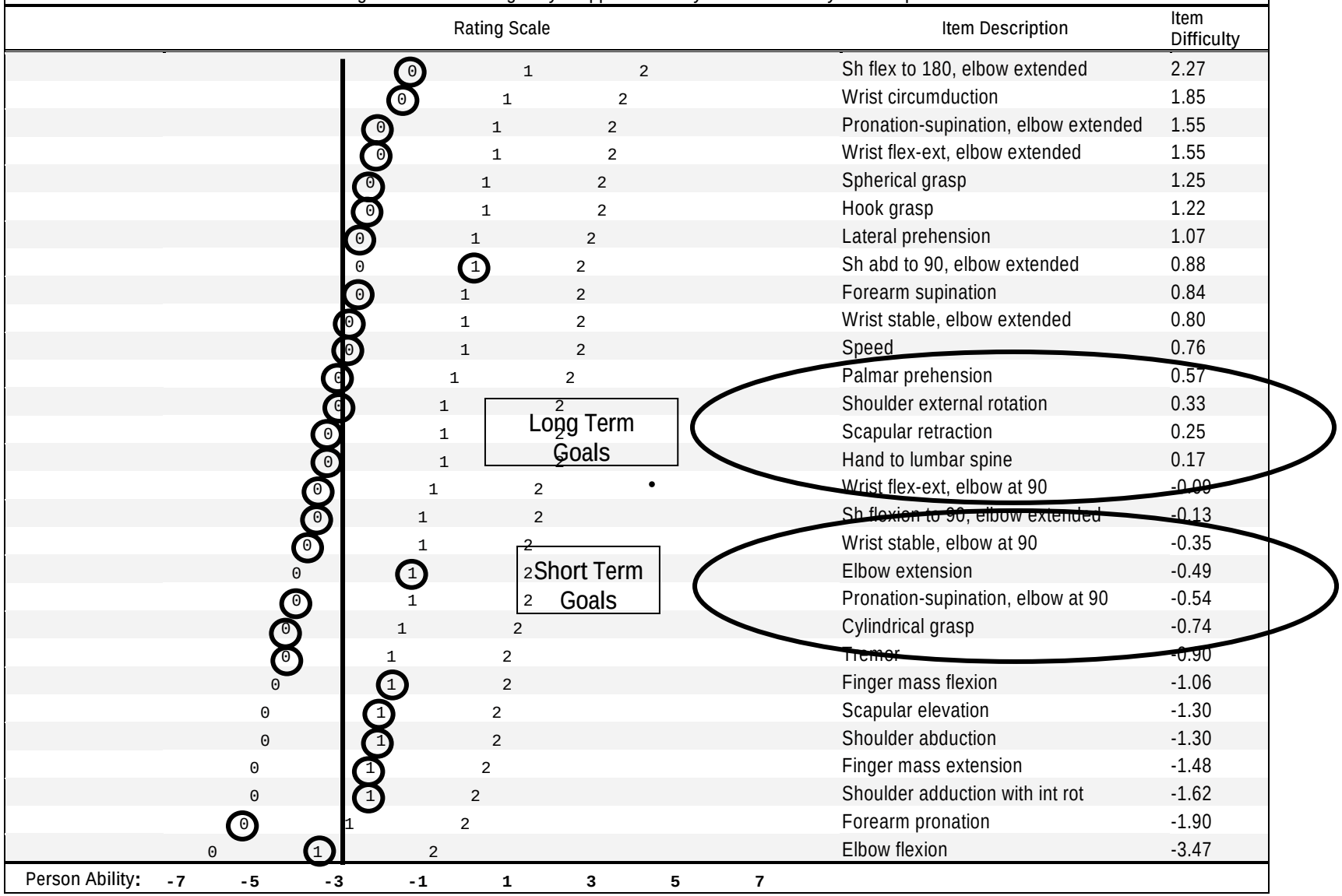


Figure 1: Modified Fugl-Meyer Upper Extremity Assessment Keyform Output



Woodbury, M. L., & Velozo, C. A. (2005). Potential for outcomes to influence practice and support clinical competency. *OT Practice*, *10*(10), 7-8

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Combining Rasch Measurement with Computer Adaptive Testing (CAT) Technology

Velozo, C., Piantieri, S., Byers, K., Pomeranz, J., Lehman, L, Wang, Y., Wen, P-S., Wang, J-H.

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ICF Activity Measure

ICFmeasure.com

A Computer Adaptive Survey Designed to Better Understand the Experiences of Individuals with Injuries and Disabilities

Click Here to Take the Full Survey

Click Here to Take a Demonstration Survey (Displays Measurement Statistics for Each Survey Response)

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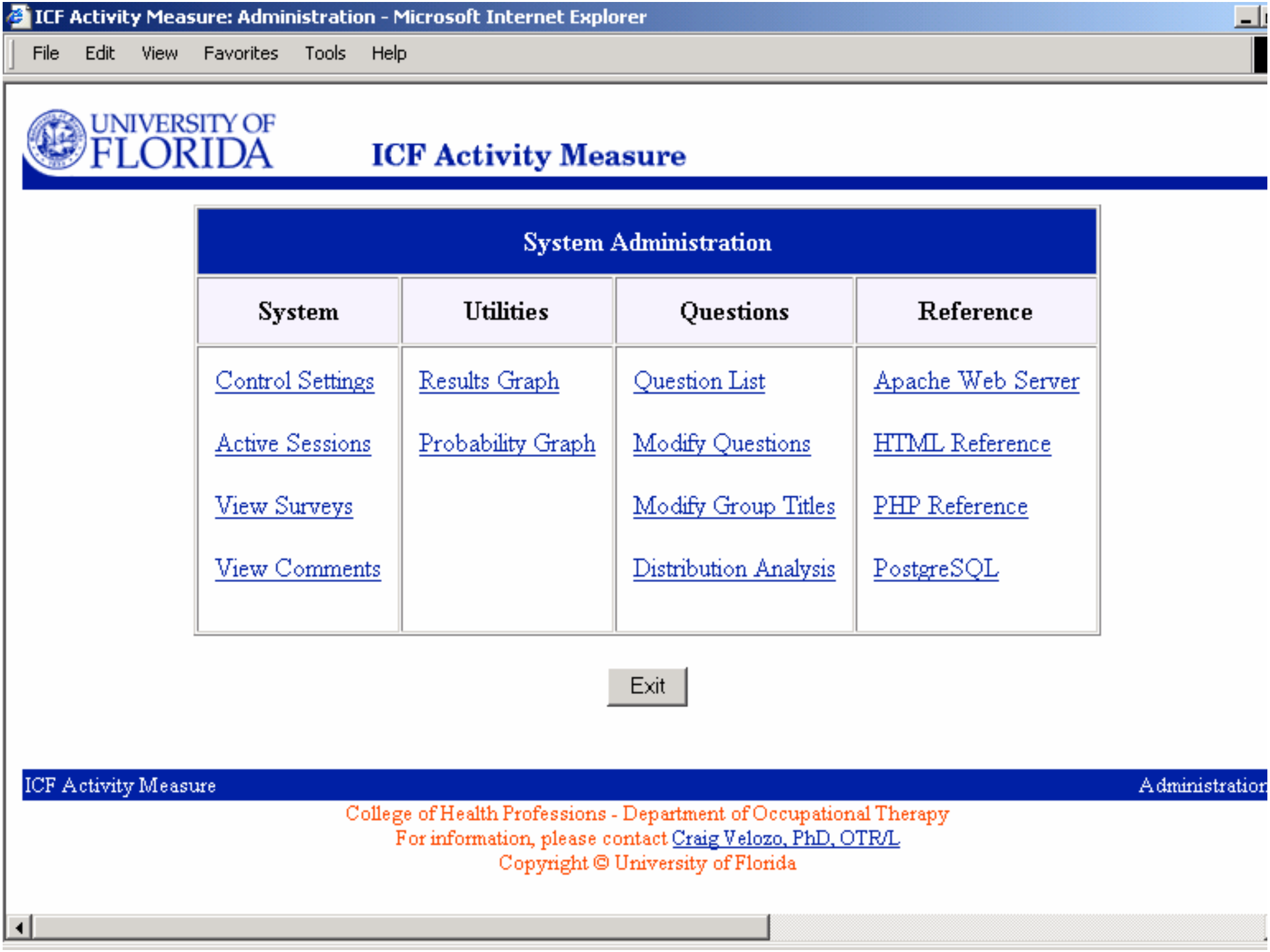
For information, please contact Craig Velozo, PhD, OTR/L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ICF Activity Measure
System Administration
System
Utilities
Questions
Reference
Control Settings
Active Sessions
View Surveys
View Comments
Results Graph
Probability Graph
Question List
Modify Questions
Modify Group Titles
Distribution Analysis
Apache Web Server
HTML Reference
PHP Reference
PostgreSQL
Exit
ICF Activity Measure
Administration
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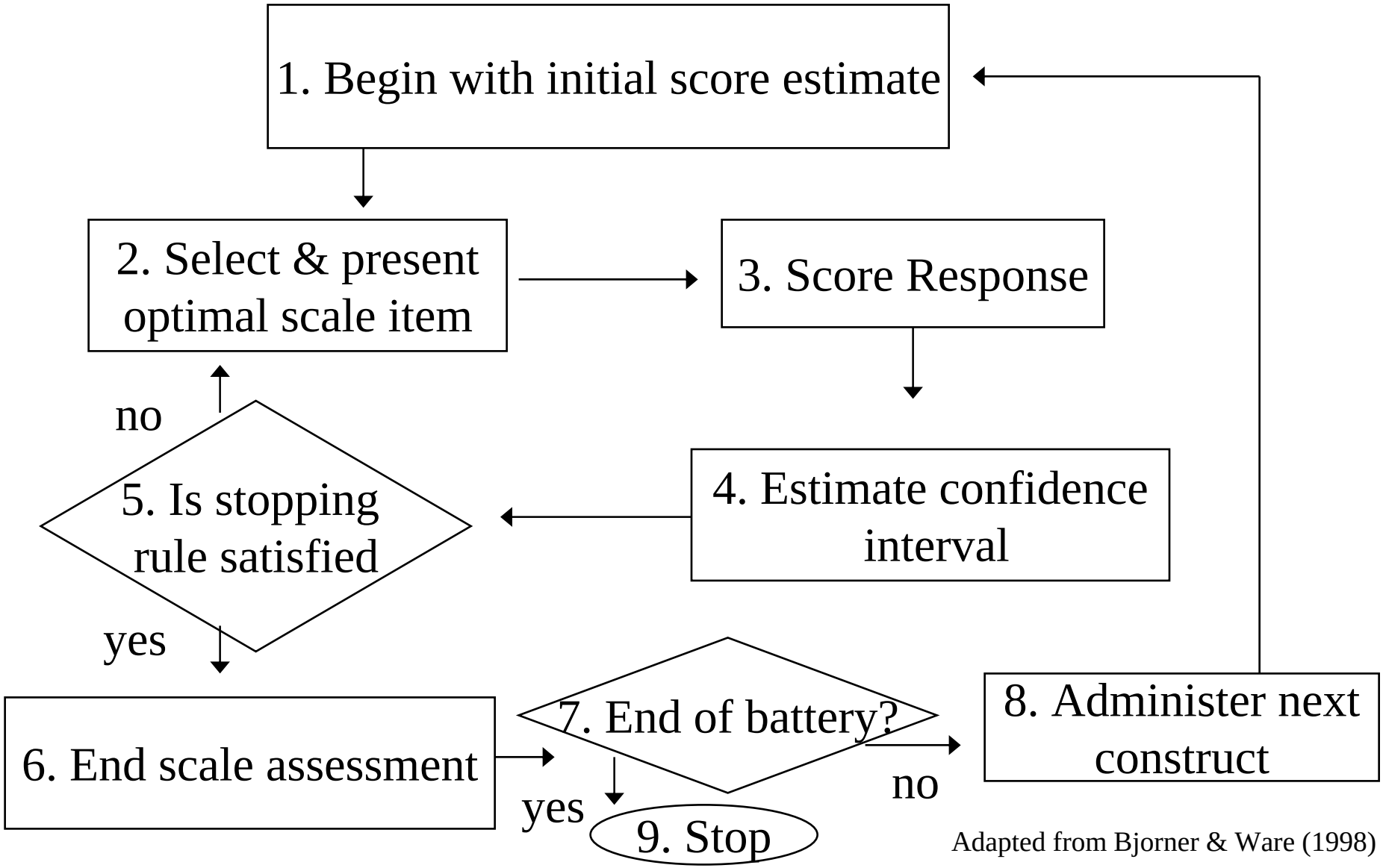
ICF Activity Measure

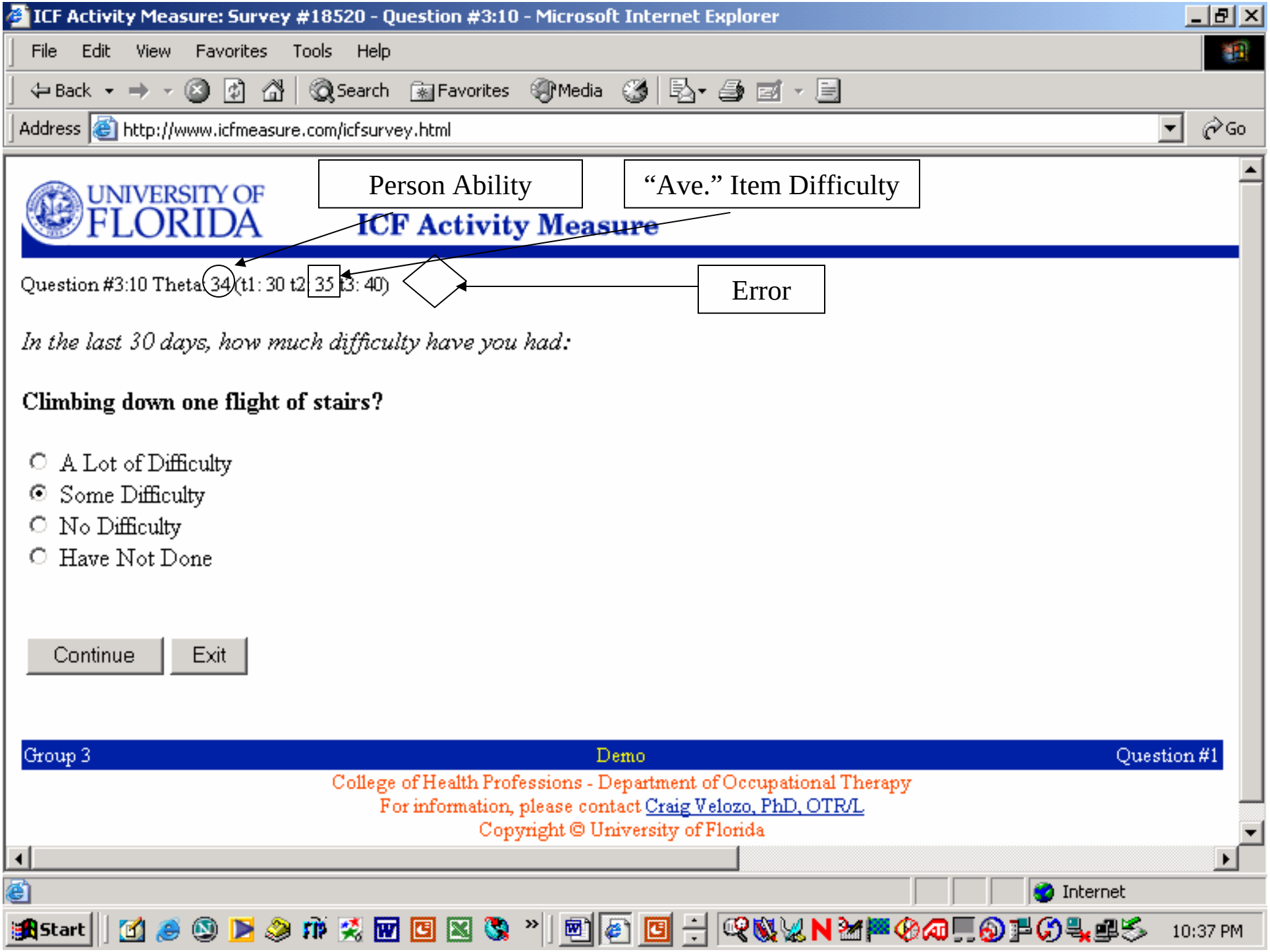
Group 1 - Positioning/Transfers

#	Question Text	t1	t2	t3	Excp.
1	Staying in a lying position on your favorite side for 1 hour (while making only minor adjustments)	5	10	15	
2	Staying in a lying position on your favorite side for 2-4 hours (while making only minor adjustments)	7	12	17	
3	Staying in a lying position on your favorite side for 5-8 hours (while making only minor adjustments)	10	15	20	
4	Staying in a lying position on your back for 1 hour (while making only minor adjustments)	8	13	18	
5	Staying in a lying position on your back for 2-4 hours (while making only minor adjustments)	11	16	21	
6	Staying in a lying position on your back for 5-8 hours (while making only minor adjustments)	13	18	23	
7	Staying in a lying position on your stomach for 1 hour (while making only minor adjustments)	10	15	20	
8	Staying in a lying position on your stomach for 2-4 hours (while making only minor adjustments)	12	17	22	
9	Staying in a lying position on your stomach for 5-8 hours (while making only minor adjustments)	15	20	25	
10	Staying in a seated position for 10-20 minutes (in your favorite chair while making only minor adjustments)	5	10	15	
11	Staying in a seated position for 30-60 minutes (in your favorite chair while making only minor adjustments)	8	13	18	
12	Staying in a seated position for 1-2 hours (in your favorite chair while making only minor adjustments)	11	16	21	
13	Staying in a seated position for 3-4 hours (in your favorite chair while making only minor adjustments)	13	18	23	
14	Staying in a standing position for 10-20 minutes (while making only minor adjustments)	15	20	25	WALK
15	Staying in a standing position for 30-60 minutes (while making only minor adjustments)	18	23	28	WALK
16	Staying in a standing position for 1-2 hours (while making only minor adjustments)	21	26	31	WALK

Computerized Adaptive Testing Algorithm



Adapted from Bjorner & Ware (1998)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Address http://www.icfmeasure.com/icfsurvey.html
Go
Person Ability
"Ave." Item Difficulty
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ICF Activity Measure
Question #3:10 Theta: 34 (t1: 30 t2: 35 t3: 40)
Error
In the last 30 days, how much difficulty have you had:
Climbing down one flight of stairs?
A Lot of Difficulty
Some Difficulty
No Difficulty
Have Not Done
Continue
Exit
Group 3
Demo
Question #1
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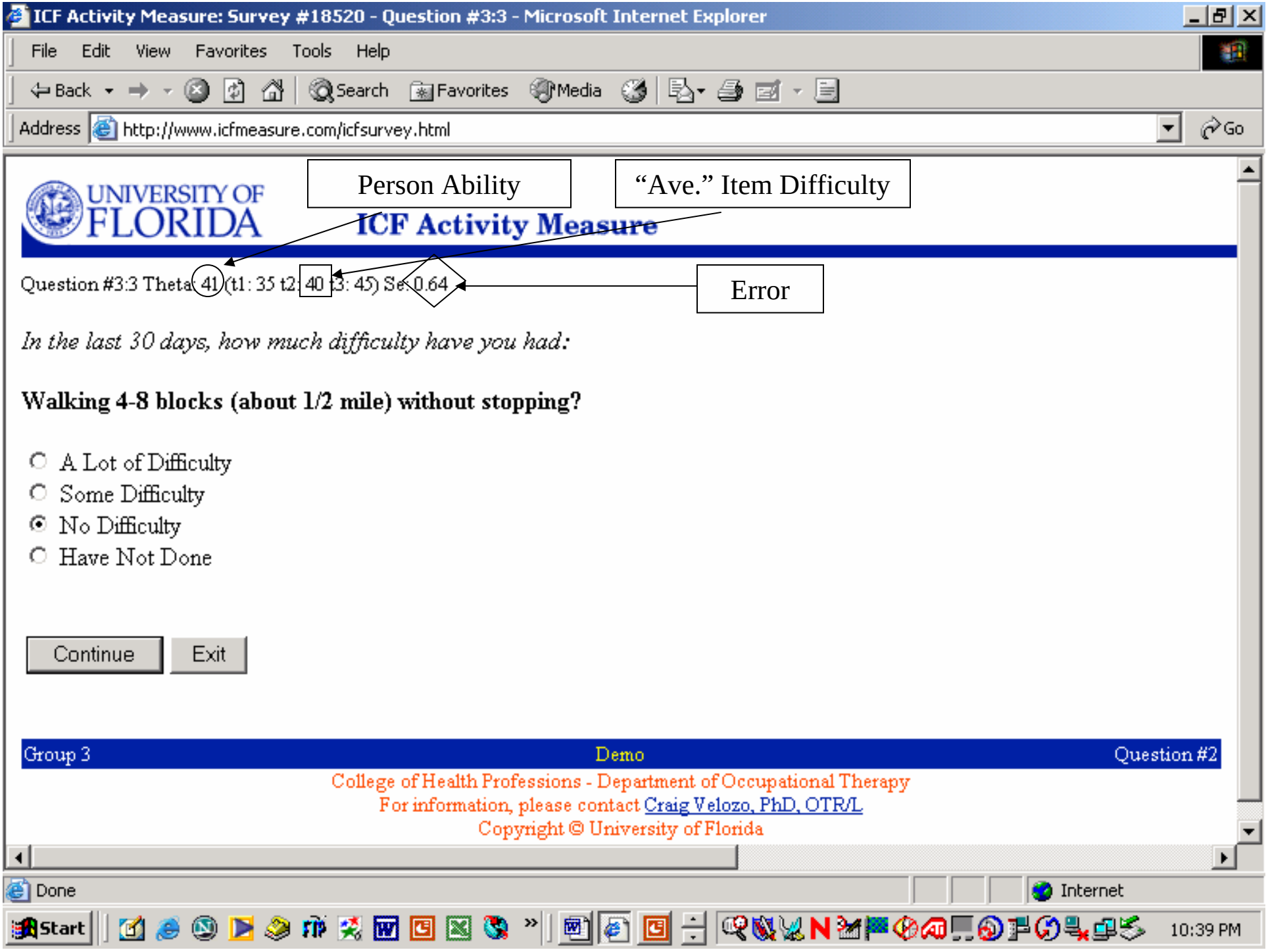
Internet
Start
10:37 PM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Go
Person Ability
"Ave." Item Difficulty
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ICF Activity Measure
Question #3:3 Theta: 41 (t1: 35 t2: 40 t3: 45) Se: 0.64
Error
In the last 30 days, how much difficulty have you had:
Walking 4-8 blocks (about 1/2 mile) without stopping?
A Lot of Difficulty
Some Difficulty
No Difficulty
Have Not Done
Continue
Exit
Group 3
Demo
Question #2
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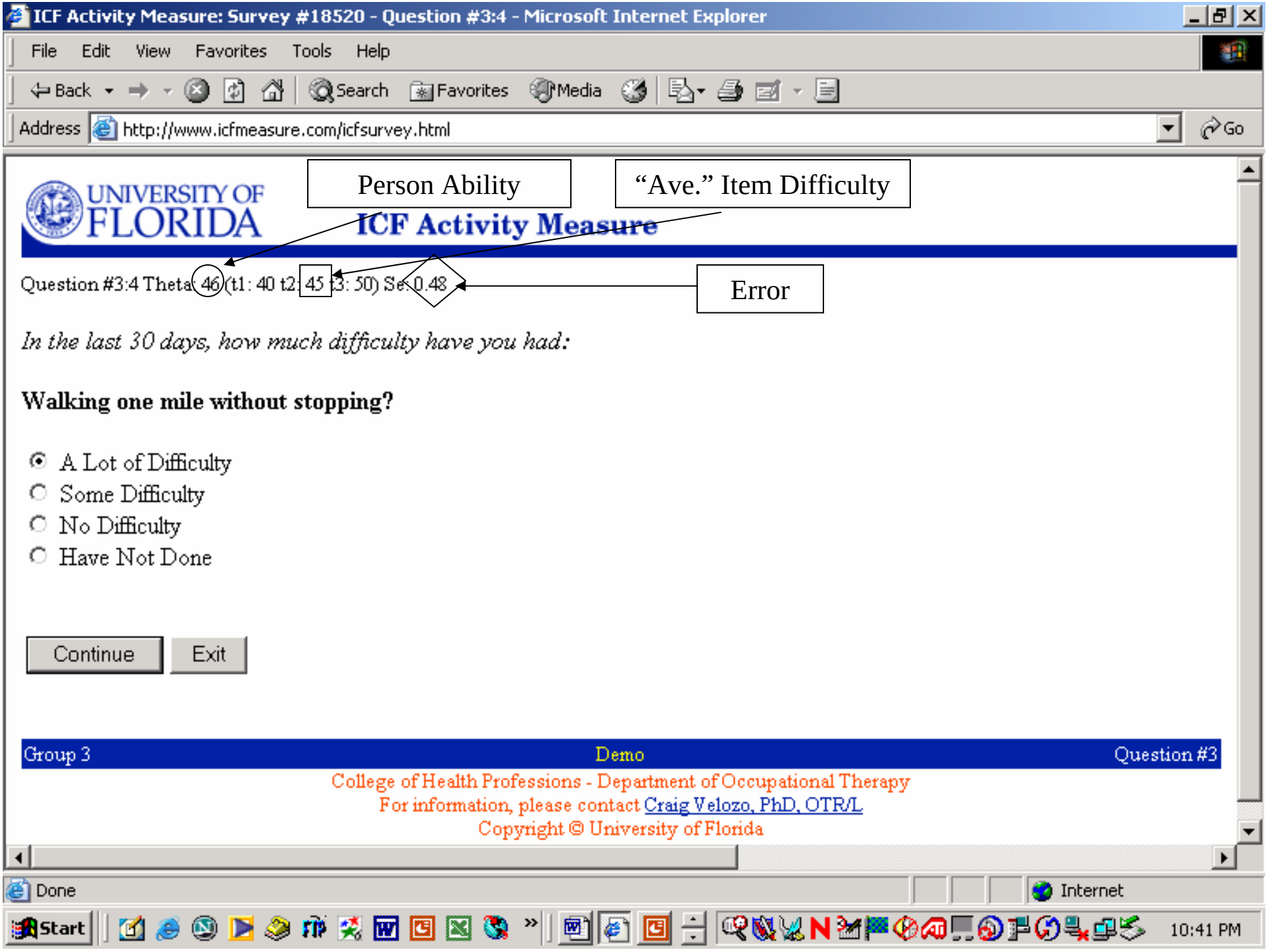
Done
Internet
Start
10:39 PM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Back Search Favorites Media
Address http://www.icfmeasure.com/icfsurvey.html
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Person Ability
"Ave." Item Difficulty
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ICF Activity Measure
Question #3:4 Theta: 46 (t1: 40 t2: 45 t3: 50) Se: 0.48
Error
In the last 30 days, how much difficulty have you had:
Walking one mile without stopping?
A Lot of Difficulty
Some Difficulty
No Difficulty
Have Not Done
Continue
Exit
Group 3
Demo
Question #3
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Done
Internet
Start
10:41 PM

ICF Activity Measure: End of Survey #20050 - Thank You! - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://icfmeasure.com/icfsurvey.html Go

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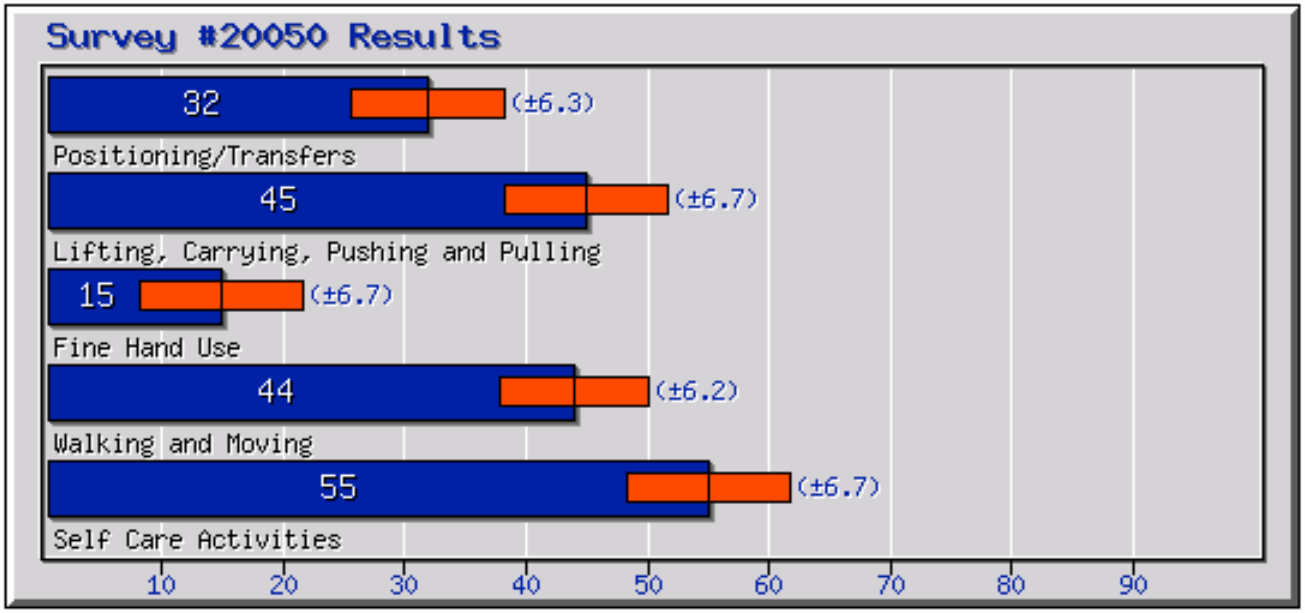
ICF Activity Measure

This concludes the survey, thank you for your participation!



Survey Results Graph

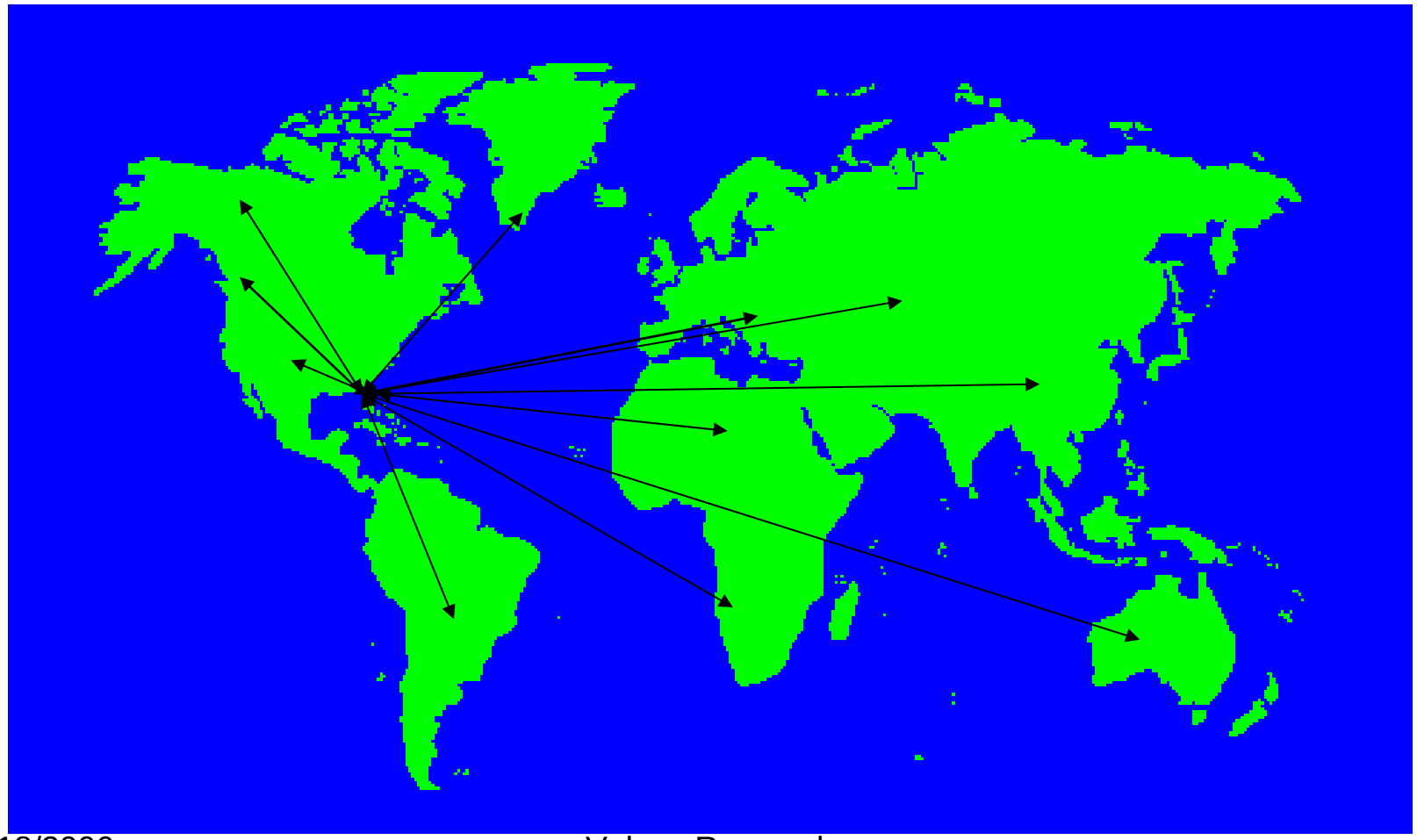
Done Internet

Draw AutoShapes

Slide 20 of 22 VA RORC 2004

Start 12:59 AM

Data Delivery



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Summary

- Scores are not measures
- Measures offer a number of advantages over scores
  - Test/Modify Theory
  - Inform Treatment (i.e., determine the next level of intervention)
- Rasch Measurement in Combination with Computer Adaptive Testing Technology
  - Efficiency
  - Precision

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Acknowledgements

- Michelle Woodbury
- Sherileen Classen
- Sande Piantieri
- Kathy Byers
- Jamie Pomeranz
- Leigh Lehman
- Inga Wang
- Pey-Shan Wen
- Jia-Hwa Wang
- Neila Donovan
- Yi-Po Chiu
- Stacy Fritz
- Dee Kornetti
- Bongsam Choi
- William Mann
- Pam Duncan
- Dept of Education, NIDRR H122G000227